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ABSTRACT

Contained are summaries of support courses for a Bachelor of Engineering Technology (BET) Curriculum in Water Quality Management. Suggested courses in this volume include: math, physics, English, drafting, mechanics, civil engineering, and economics. Also included are self-appraisal suggestions for institutions considering implementation of this program and appendices on licensing and accreditation. (CS)

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A BACHELOR OF ENGINEERING TECHNOLOGY CURRICULUM IN WATER QUALITY MANAGEMENT

ED174453

PROGRAM IMPLEMENTATION

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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A Bachelor of Engineering Technology Curriculum in Water Quality Management Program Implementation

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Division of Manpower Training
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Introduction

Manpower Need

The Clean Water Act of 1977 (PL95-217) dictates that actions have to be taken to improve the quality of our nation's water. Water quality management is required under many sections of the Act but it is especially apparent under Sections 201 and 208. Section 201 requires water quality management, as well as planning, since construction of treatment works for point-sources must provide for best practicable treatment technology, areawide treatment plans, and revenue production through recycling and reclamation.

Section 208 of this same law specifically requires water quality management planning for both point and non-point sources. The planning and implementation process has just begun for most areas of the United States and the manpower requirements will peak several years from now. In conjunction with construction of facilities a monitoring, surveillance, and enforcement program must also be maintained. Thus intensive training must continue over the next decade to meet the manpower needs for local, state, and federal agencies and private firms.

Much of this required manpower effort can be supplied by engineering technologists. The persons planning, monitoring, and enforcing the water quality must have basic skills in science and engineering combined with up-to-date applied knowledge of water quality management. A Bachelor of Engineering Technology (BET) degree in Water Resources Engineering Technology can be the key to this need.

Training Program

Purpose

The objective of this project is to extend the scope of the national wastewater treatment and operation training programs which provide two-year post-high school and four-year post-high school training. This degree program will provide for: (1) graduates of high school to take a four-year program, and (2) graduates of associate degree programs to continue through an additional two-year program, leading to a BET with a major in Water Quality Management (WQM). These graduates will be qualified to fill the needs of the country for a major responsibility in Section 201 and 208 implementation. The objective of the program is to produce a graduate who has both the basic engineering and the applied technology skills necessary to perform this work satisfactorily. This objective is accomplished by including applied subject matter in the curriculum and by elimination of some seldom needed theoretical subject matter.

Approach

This program is designed as a companion program to that developed for the U.S. Environmental Protection Agency entitled *A Four-Year Wastewater Technology Curriculum*,* which built upon several of the existing BET degrees in the water and wastewater field. The approach taken in this project was to utilize the knowledge of those existing programs and then:

1. determine the tasks that had to be performed for water quality management;
2. determine the positions that a graduate from a BET program with a major in Water Quality Management could fill;
3. determine how the graduate would fit into professional licensing systems;
4. develop courses for the curricula based on the required qualifications determined under 1 and 2; and
5. develop program implementation procedures.

**Program Implementation: A Four-Year Wastewater Technology Program* J. A. Chisman and W. A. Wockenfuss, Project Directors. U.S. EPA, August 1976.

Water Quality Management Skills

An advisory committee was organized in the earliest stages of the work to assist in the delineation of the needs of the individuals implementing Sections 201 and 208. The members included representatives of regional and county planning agencies, local government, engineering and planning consultants, U.S. EPA, and state agencies. Using this committee, lists of position titles and job descriptions were developed for the graduates. Table I compares the potential tasks that might be performed by a BET in WQM within various organizations. Certain of these tasks appear common to several organizations and a condensation of these is shown in Table II. The condensed list was then used to emphasize the required subject matter for inclusion in courses during discussions with the advisory committee. A specific example showing areas of work and job titles performed within the Pennsylvania Department of Environmental Resources is shown in Appendix I.

TABLE I

ORGANIZATIONAL TASKS OF BET GRADUATES IN WQM

Place of Employment	Tasks
1. Governmental Agencies	
a. Federal	Stream surveys, laboratory analyses, plan and specification review, investigation of and reporting on complaints, public relations, and interpretation and enforcement of laws and regulations.
b. State	Planning, surveillance, review, monitoring, public participation negotiation, and emergency preparations.
c. Local	Similar to planning agency if local government has taken over the 208 planning.
2. Planning Agency	Planning, population projections, primary data collection, water quality modeling, and non-point source wastewater management.
3. Drainage Basin Commissions	Similar to planning agency.
4. Consulting Engineers	Preparation of studies and assessments of environmental projects, application of established engineering principles to layouts of systems, scheduling work, making preliminary investigations, and collecting data. Specific tasks involve computer applications, water quality sampling, hydrologic analyses, treatment process analyses, cost-effectiveness analysis, environmental inventories, institutional evaluations, report writing, and project management.

TABLE II

CONDENSED LIST OF POSSIBLE TASKS TO BE PERFORMED BY BET GRADUATES IN WQM

1. Environmental inventories
2. Population projections
3. Coordination of public participation activities
4. Stream surveys
5. Hydrologic analysis
6. Computer applications
7. Wastewater treatment process and sewer system plan reviews, evaluation, and inspection
8. Cost-effectiveness analysis
9. Report writing and public speaking
10. Project coordination and management – CPM/PERT
11. Non-point source reviews and evaluations
12. Water supply distribution system reviews, evaluation, and inspection

Self-Appraisal Suggestions

For Institutions Considering Implementation of this Program*

Philosophy and Purpose

The institution should be convinced of the desirability and effectiveness of Bachelor of Engineering Technology programs. It should be alert to the need for such programs, in general, and for an environment-related technology instructional program, in particular. The institution may be either public or private, profit or nonprofit, but it should possess the following characteristics:

1. place a clear emphasis on professional preparation as one of its purposes;
2. offer post-secondary instruction leading to a bachelors degree; and
3. accept students who wish to transfer into its instructional program from two-year associate degree programs.

Program Advisory Board

The institution should utilize the services of an advisory board.

The board should be appointed at the onset of the curriculum development and should assist in the following activities:

1. curriculum implementation decisions;
2. recruitment of students for the program;
3. placement of students for summer internships;
4. placement of graduates upon completion of the program;
5. acceptance of the graduate by civil service systems and other employing, licensing, and certifying organizations; and
6. improvement of equipment and facilities at the educational institution.

The Advisory Board should be appointed by the officials of the institution in consultation with the director of the WQM program, officials of regional business and industries related to water quality management, and the regional director of EPA. The latter should be included as a member of the board.

The Advisory Board should be composed of not less than seven members representing regional and local organizations, as well as professional groups having concern for water quality management and related occupations. The members may represent, but not be limited to, the following:

1. state agencies governing the registration and qualifications of wastewater treatment employees;
2. state water pollution control authorities;
3. regional planning agencies;
4. state civil service or merit systems;
5. personnel or education committees of water pollution control associations;
6. water and wastewater equipment manufacturers and their associations;
7. practicing wastewater treatment operators;
8. municipal leagues;
9. professional sanitary engineers and professional planners;
10. professional educators from other institutions; and
11. industries having wastewater treatment facilities.

Each member should be appointed for a period of two or three years, in such a manner that not more than one-half of the members will be replaced in a single year. Members should not be precluded from service with other organizations or committees. The institution should provide the necessary funding for the meetings of the board.

Meetings should be called by the chairman not less than once each year and more frequently at the onset of the program. The chairman will be responsible to guide board activities for the institutional

*Adapted from *Program Implementation: A Four-Year Wastewater Technology Program.* J. A. Chisman and W. A. Wockenfuss, Project Directors. U.S. EPA, August, 1976.

program. The board should also assist the institution in conducting a self-evaluation of the program and in preparing a written report that reflects how the institution has met the various criteria that have been set.

Administrative and Institutional Support

The institution must exhibit a clear interest in a Water Quality Management technology instructional program and be willing to provide administrative support for such a program; this must include adequate financial support to sustain the program during its starting stage. Funds must be budgeted for professional development of instructional staff, including opportunities for contact with other professionals at local, state, and national levels. The budget should include items for instructors' travel and participation in professional meetings on a regular basis. A reasonable minimum of such activities might include:

1. national meeting annually;
2. professional seminars semiannually;
3. continuing education course(s) annually;
4. professional society (local) at the discretion of the instructor; and
5. seminar or short course study of advances in instructional technology, including innovative teaching techniques, annually.

The institution should provide and maintain an active student personnel services department which will meet the following student needs:

1. provide student counseling services;
2. maintain student records;
3. support and assist in organizing programs of student activities;
4. furnish adequate health services;
5. offer financial advice and assistance when needed;
6. assist in location of student housing; and
7. provide for student testing and evaluation.

The institution should provide adequate ancillary personnel that can efficiently and effectively conduct noninstructional activities in support of the instructional program. This would include secretarial assistance and laboratory assistants.

Course suggestions for a water quality management curriculum are given on pages 11 through 12. During the initiation of the program, the administration should plan to reduce the work load for instructors to give them time to plan and organize the program.

Curriculum

The curriculum is suited for self-paced instruction. If the institution chooses to implement a self-paced course, it will mean that time requirements must be kept flexible, and adequate guidance and help should be provided for each student. The student should learn to take the major responsibility for planning and learning. At all times the student should be a participant, and not merely a spectator, in the learning process. Many students do not take the proper planning or pacing responsibility; therefore, considerable effort must be made by the instructors to develop these skills.

Effective instructional sessions are of utmost importance. Students should receive feedback concerning their progress. Instructors should constantly evaluate learning activities on the basis of their effectiveness in the promotion of learning.

Instructional Staff

Instructors in the technical courses should have at least an M.S. degree and five years of full-time work experience. Another alternative might be to provide existing staff with background to qualify them for teaching the courses through part-time work, projects, or sabbaticals.

Physical Facilities

Adequate classroom, laboratory, storage, and noninstructional space must be available to accommodate the number of students, staff, and equipment to be housed in the area. Plans should be made to expand the facilities if enrollment increases.

Recruitment

The institution should have or initiate a plan for recruiting students. This program should cover a wide geographic area. It should include communicating with secondary schools, two-year associate

degree schools, the general public, and various commercial and civic organizations, especially those connected with the wastewater treatment field.

Recruiting brochures, pamphlets, and announcements must be factual and accurately stated and should be presented in a manner that will bring credibility to the program.

Admissions policies should be flexible and allow individuals to enter who have graduated from or attended two-year technical programs if they can demonstrate the desire and the capability to succeed in the program.

Employees in environmental fields should be encouraged to enroll if they are qualified; however, there should be adequate modification of their educational program in consideration of their knowledge and skill.

Characteristics of Students

There are few, if any, objectively qualified measures of student characteristics that might be useful in selecting students for the program. The educational institution should develop and use objective measures in the student recruitment and selection process whenever it is possible. Because of the great variety in background and experience of potential students, a great deal of flexibility must be permitted in selecting students. The present document will offer only general guidance in student selection. Applicants may be classified into one of the following general categories:

1. high school graduates without work experience;
2. high school graduates with work experience;
3. two-year associate degree graduates without work experience;
4. two-year associate degree graduates with work experience;
5. persons having some experience who have completed one or more technical courses above high school level; and
6. persons having a four-year bachelor's degree in a non-engineering field who desire training in engineering technology.

Applicants in each of these groups must be given special consideration in selecting them for admission, as well as in planning for their instruction. Advanced standing should be available to qualified applicants. Applicants should be screened on the basis of the following characteristics:

1. *Evidence of academic ability*. There should be adequate evidence, either from school reports, entry tests, CLEP scores, or in-depth interviews, that the applicant is interested in a career in wastewater technology and is capable of academic achievement.
2. *Aptitudes*. Information on aptitudes might be obtained from simple performance tests with particular attention given to laboratory-related skills.
3. *Interests*. The applicant should be interested in the quality of the environment, in applied science (particularly as it relates to wastewater treatment operations), and in public service that frequently involves less prestige and influence.
4. *Temperament*. The applicant should: a) be able to get along well with others, both as a supervisor and as a subordinate, b) be responsible in the face of political, regulatory, and public scrutiny and criticism, c) maintain quality performance, and d) be willing to accept the responsibility for the safety and welfare of him/herself, fellow workers, and the general public.

Characteristics and Performance of Graduates

The graduate of a four-year wastewater technology program will have professional skill and knowledge with respect to specific procedures. The graduate will 1) have skills and knowledge sufficient to act as an integral member of monitoring, surveillance, enforcement, planning, and implementation teams, and 2) be able, with confidence and relative ease, to adapt the specific skill and knowledge acquired through the instructional program to other areas not directly dealt with in the program. General statements of the skill and knowledge that the student will acquire may be found in the section on Suggested Curriculum.

Types of Positions

Graduates should be regarded as engineering techno-

logists *and* as professionals. This implies not only competence at the hands-on-level of application in performing the basic procedures in the overall management, but also some understanding of the basic engineering principles. During the first weeks on the job, the graduate will require varying degrees of supervision in the performance of his/her tasks.

Placement

Ultimately the institution should assist the student in finding a work situation which utilizes the student's training and special capabilities in the water quality management field. Assistance should be provided by the institution in arranging interviews with appropriate organizations in the wastewater treatment field.

There should be a follow-up of graduates after employment to assist and counsel them in achieving advancement and to provide feedback to the institution that may help to improve or update the instructional program.

Public Relations

An adequate public relations program is essential to the success of a water quality management instructional program. Close ties between the school and the public should be developed to provide support for the institution's goals. The public relations program should provide information about potential applicants and the success of graduates. It should also help identify potential members for the institutional advisory board, as well as promote local financial support for the institution.

Suggested Curriculum

The graduate of the WQM program should be first an engineering technologist and second a WQM specialist. This is necessary so that the student has maximum flexibility in choosing career opportunities. Even though professionally-oriented training is an objective of the BET program, training so specific that it prevents the understanding of basic engineering concepts is shortsighted. Professional licensing of the graduate is also advantageous for career advancement. Licensing as an engineering technologist is not available and licensing as a technician is not appropriate for the graduates of a four-year engineering technology curriculum, therefore the curriculum is designed so that the student is prepared to take the Engineer-in-Training exams. Successful performance on this exam permits placement of the BET graduate in an engineering position with the Federal Civil Service.* After sufficient experience and satisfactory examination, the BET graduate may eventually be licensed as a professional engineer.** More aspects of the licensing are discussed in Appendix II.

The program from which the engineering technologist graduates should be accredited. Accreditation allows for acceptance into positions in the engineering technology field, as well as eventual licensing, because it assures that the program and the standards by which students are judged meets minimum acceptable levels. The "Engineers Council for Professional Development" is responsible for the accreditation. (See Appendix III for a detailed discussion of the BET accreditation requirements.) The minimum course work that a student will have completed upon graduation from the recommended curriculum is shown in Table III. The credits associated with the various subject areas is the best estimate for the required exposure based on other experience or recommendation.

Graduates of the program are exposed in depth to management of water quality. This includes planning, treatment and control theory, operation, surveillance, and monitoring. Since the program emphasizes applied engineering, most courses contain laboratory sessions. Detailed projects, field trips, and lectures by practicing engineers, planners, and government officials expose the students to current methods and procedures.

Table IV suggests a four-year BET curriculum in which the student continues in the same program throughout the four years of study. Upon completion of the program the student will have taken a minimum of 132 semester credit hours of instruction.

Upper Division Concept (2 + 2)

The upper division concept has only come into use in academic institutions since the second world war. The concept spread with the increase in the number of community colleges and technical schools which offer the high school graduate an opportunity for a two-year associate degree or the first two years of a four-year program. Two-year colleges offer many programs in liberal arts, fine arts, and the physical, chemical, and biological sciences which enable a student to transfer easily to a four-year institution. However fewer transfer programs are available for the engineering technology fields and most graduates of two-year engineering technology programs cannot go directly into the junior year in an engineering four-year degree program.

In recent years, students completing two-year technician and technology programs in the water quality control field have sought opportunities to transfer to BET programs. This has only been possible at a few locations and has not provided specific training in WQM.

One of the purposes of this Bachelor of Engineering Technology Curriculum project was to develop several approaches to the upper division concept for students in the water quality control field. The

*U.S. Civil Service Commission. *Opportunities in the Federal Government, Engineering, Physical, and Mathematical Sciences & Related Professions.* Announcement No. 424, May 1977.

**National Society of Professional Engineers. *Report of Task Force on Four-Year Technology.* Washington, DC. NSPE Pub. No. 2009 M&N 3-73. Revised 2-75.

following constraints were considered in the development:

1. All course guides should be written in performance terms.
2. Courses in the performance-oriented two-year curricula should be made equivalent to each other and to courses in the four-year curriculum.
3. The courses and curriculum should be designed to meet accreditation requirements.
4. Course content should be reviewed by practitioners in the field representing potential employers of the program graduates, as well as instructors in two-year water quality control programs.

Table V summarizes the equivalent courses of two-year programs at Charles County Community College, Ulster County Community College, Harrisburg Area Community College, and The Commonwealth Campus System of The Pennsylvania State University. Review of the preparation of the students indicates that a fairly good match occurs between the programs and that in most instances the proposed BET curriculum could be completed in two academic years following the associate degree.

The Capitol Campus of The Pennsylvania State University was conceived in the late sixties in the framework of an upper division and graduate program. It has operated a highly successful 2 + 2 BET Program in Water Resources Engineering Technology in the Design and Operation track. The Water Quality Management track is currently being implemented so the transferability of students into the program is of prime concern. Typical curricula at The Pennsylvania State University, Capitol Campus, for two-year graduates with associate degrees from the Charles County Community College Pollution Abatement Technology and Harrisburg Area Community College Civil Engineering Technology programs are listed in Table VI. A good match occurs and a reasonable schedule is possible at Capitol Campus.

TABLE III

CURRICULUM FOR THE BACHELOR OF ENGINEERING TECHNOLOGY DEGREE IN WQM

Upon graduation from the program, the student will have successfully completed courses in the following areas of study during his first four years of college:

*English, Composition, and Speech - 6 or more credits
*Humanities and Social Science - 15 credits
*Graphics - 2 credits
*Physics - 6 credits
*Mechanics - statics, dynamics, and strength of materials, 6 credits
*Mathematics - minimum coverage is through an introduction to ordinary differential equations, 15 credits
*Statistics - distributions and testing, 3 credits
*Biology - 3 credits
*Chemistry - general through introduction to organic, 8 credits
*Plane Surveying and Engineering Surveys - 6 credits
**Applied Electricity - AC and DC circuits and motors, 2 credits
*Engineering Economy - 2 credits
*Elementary Structural Design - reinforced concrete and steel - 3 credits
*Engineering Construction Materials - concrete, steel, and soils (material properties, testing methods, material usage, mixture design), 3 credits
*Computer Programming - Fortran IV language, program writing, solutions to engineering problems, 3 credits
*Technical Writing - 2 credits
*Fluid Mechanics - fluid flow theory, pipe flow, open channels, and flow measurement; 3 credits, lecture; 1 credit, lab
*Water/Wastewater Chemistry and Microbiology - 3 credits, lecture; 2 credits, lab
Water Pollution Abatement - stream sanitation and wastewater treatment from point and non-point sources, 5 credits
Hydrology and Water Supply - groundwater and surface water, water treatment theory, and water distribution, 4 credits
Operation and Control of Treatment Plants - unit operations lab and analytical procedures necessary for operation, 4 credits
Environmental Sanitation - integrates epidemiology with various aspects of wastewater, solid waste and air pollution control, 3 credits
Water Quality Management - relationships of water quality management planning to public laws and needs, 3 credits
Water Quality Management (WQM) Internship - ten weeks of full-time service at an agency or firm performing WQM related tasks, 3 credits
Selected Technical Electives - could include regional planning, treatment plant design, and air pollution, 8 credits

*Courses required to meet accreditation requirements of ECPD.
**Additional courses necessary to prepare students as Engineers-in-Training.

TABLE IV

SUGGESTED FOUR-YEAR WQM TECHNOLOGY CURRICULUM

Year	Semester	Course	Title	Credits
I	I	English I	Fundamental Composition and Rhetoric	3
I	I	Math I	College Algebra/Trigonometry	4
I	I	Chemistry I	Chemistry I	4
I	I	Humanities	Humanities Elective	4
				15
I	II	English II	Technical Writing	3
I	II	Math II	Technical Math with Calculus	3
I	II	Chemistry II	Chemistry II	4
I	II	Biology	Biology	3
I	II	Social Science	Social Science Elective	4
				17
II	I	Physics I	Fundamental Physics	4
II	I	Drafting I	Fundamental Drafting	2
II	I	Math III	Applied Calculus	4
II	I	Mechanics I	Statics	4
				14
II	II	Physics II	Technical Physics	4
II	II	Math IV	Applied Calculus & Differential Equations	4
II	II	Mechanics II	Strength of Materials	4
II	II	Chemistry III	Water/Wastewater Chemistry and Microbiology	5
				17
III	I	Electricity I	Applied Electricity	2
III	I	Environmental Control	Environmental Sanitation	3
III	I	Civil Engineering I	Elementary Structural Design	4
III	I	Mechanics III	Dynamics	4
III	I	Surveys I	Plane Surveying	2
III	I	Civil Engineering III	Engineering Economy	2
				17
III	II	Water Quality Management	WQM Planning	3
III	II	Mechanics IV	Fluid Mechanics	4
III	II	Math V	Computer Programming	4
III	II	Civil Engineering II	Engineering Construction Materials	3
III	II	Surveys II	Engineering Surveys	2
				16
SUMMER			WQM Internship	3
IV	I	Civil Engineering IV	Water Pollution Abatement	4
IV	I	Math VI	Statistics	3
IV	I	English II	Informative Speaking	2
IV	I	Humanities	Humanities Elective	4
IV	I	Elective	Technical Elective*	4
				17
IV	II	Civil Engineering V	Hydrology and Water Supply	4
IV	II	Civil Engineering VI	Operation and Control of Treatment Plants	4
IV	II	Social Science	Social Science Elective**	4
IV	II	Elective	Technical Elective*	4
				16
			Total	132

*Suggest public administration or planning course.
**Suggest course related to impact of technology on man and the environment.

TABLE V-a

EQUIVALENT COURSES IN ENVIRONMENTALLY-ORIENTED ASSOCIATE DEGREE PROGRAMS AND THE PROPOSED BET PROGRAM IN WQM

Proposed WQM Program	Charles County Community College Pollution Abatement Technology	Ulster County Community College Water Quality Management
Fundamental Composition and Rhetoric	ENG 101	ENG101
Technical Writing	ENG 205	ENG 227
Informative Speaking	SPH 103	
College Algebra and Trigonometry	MTH 150	MTH 105
Technical Math with Calculus	MTH 102	
Applied Calculus		
Applied Calculus and Differential Equations		
Chemistry I	CHE 150	CHE 103
Chemistry II	CHE 151	CHE 104
Water/Wastewater Chemistry	CHE 252,	ENV 101, 102
Microbiology	255	MLT 207
Biology	BIO 105	ENV 131
Fundamental Physics	PHY 150	
Technical Physics	PHY 151	
Fundamental Drafting		
Statics		
Strength of Materials		
Dynamics		
Fluid Mechanics		
Elementary Structural Design		
Engineering Construction Materials		
Engineering Economy		
Computer Programming		
Plane Surveying		
Engineering Surveys		ENV 205
Applied Electricity		
Statistics		MAT 211
Environmental Sanitation	PAT 101	
Water Quality Management		
WQM Internship		
Water Pollution Abatement	PAT 10[illegible], 205	
Hydrology and Water Supply		
Operation and Control of Treatment Plants	PAT 203, 109	
Technical Electives	PAT 109	ENV 103, 204, 201, 202
Social Science and Humanities Electives		HIS 101, 102

TABLE V-b

EQUIVALENT COURSES IN ENGINEERING-ORIENTED ASSOCIATE DEGREE PROGRAMS AND THE PROPOSED BET PROGRAM IN WQM

Proposed WQM Program	The Pennsylvania State University Commonwealth Campuses Mechanical Engineering Technology	Harrisburg Area Community College Civil Engineering Technology
Fundamental Composition and Rhetoric	ENG 800	ENG 101
Technical Writing	ENG 826	ENG 104
Informative Speaking	SPH	SPH 101
College Algebra and Trigonometry	MTH 801	MTH 103
Technical Math with Calculus	MTH 802	MTH 104
Applied Calculus	MTH 803	
Applied Calculus and Differential Equations		
Chemistry I		CHM 101
Chemistry II		CHM 121
Water/Wastewater Chemistry and Microbiology		
Biology		
Fundamental Physics	PHS 150	PHS 201
Technical Physics	PHS 151	PHS 202
Fundamental Drafting	EG 1	ENG 101
Statics	E MCH 811	CVL DRFT 122
Strength of Materials	ME 805	
Dynamics	E MCH 813	CVL TCH 208
Fluid Mechanics		
Elementary Structural Design	AE 809	CVL TCH 201
Engineering Construction Materials		
Engineering Economy		GEN TCH 262
Computer Programming	CMP SC 1	MTH 153
Plane Surveying		CVL TCH 104, 205
Engineering Surveys		
Applied Electricity		ELEC 100
Statistics		
Environmental Sanitation		
Water Quality Management		
WQM Internship		
Water Pollution Abatement		CVL TCH 207
Hydrology & Water Supply		CVL TCH 206
Operation & Control of Treatment Plants		
Tech Electives	EG 12, IE 811 EG 803, IE 315, EG 815, ME 810, EG 812, plus 2 other technical electives	CVL TCH 111, 101, 224, 206, 207
Social Science & Humanities Electives	Social Science & Humanities Electives	

TABLE VI

REQUIRED JUNIOR/SENIOR YEAR BET CURRICULA FOR WATER QUALITY MANAGEMENT TRACK IN WRET, THE PENNSYLVANIA STATE UNIVERSITY, CAPITOL CAMPUS

A. Tentative Curriculum for Students Transferring with an Associate Degree in Pollution Abatement Technology from Charles County Community College, LaPlata, MD.

1. Junior Year	(Semester Credit Hours)
Fall Term	
Applied Calculus	4
Plane Surveying and Engineering Surveys	4
Dynamics/Statics	4
Winter Term	
Applied Calculus and Differential Equations	4
Technical Elective	4
Social-Humanities Elective	4
Spring Term	
Applications of Computers in Engineering Technology	3
Water Quality Management	3
Fluid Mechanics	4
Summer Term	
Water Quality Management Internship	3
2. Senior Year	
Fall Term	
Introduction to Applied Statistics	3
Engineering Economy	2
Applied Electricity	2
Strength of Materials	4
Winter Term	
Hydrology and Water Supply	4
Structural Design	4
Technical Elective	4
Spring Term	
Civil Engineering Materials	4
Technical Elective	4
Social-Humanities Elective	4

B. Tentative Curriculum for Students Transferring with an Associate Degree in Civil Engineering Technology from Harrisburg Area Community College, Harrisburg, PA.

1. Junior Year	(Semester Credit Hours)
Fall Term	
Applied Calculus	4
Fundamentals of Chemistry I	4
Social-Humanities Elective	4
Winter Term	
Applied Calculus and Differential Equations	4
Fundamentals of Chemistry II	4
Dynamics	4
Spring Term	
Water/Wastewater Chemistry and Microbiology	5
Water Quality Management	3
Fluid Mechanics	4
Summer Term	
Water Quality Management Internship	3
2. Senior Year	
Fall Term	
Water Pollution Abatement	5
Applications of Computers in Engineering Technology	3
Introduction to Applied Statistics	3
Winter Term	
Hydrology and Water Supply	4
Environmental Sanitation	3
Technical Elective	4
Spring Term	
Operation and Control of Treatment Plants	4
Social-Humanistic Elective	4
Technical Elective	4

Course Descriptions

Detailed technical course guides for Biology, Chemistry I and II, Water/Wastewater Chemistry and Microbiology, Engineering Surveys, Environmental Sanitation, Fluid Mechanics, Water Quality Management, Water Quality Management Internship, Water Pollution Abatement, Hydrology and Water Supply, and Operation and Control of Treatment Plants are included in a companion publication entitled *A Bachelor of Engineering Technology Curriculum in Water Quality Management: Course Guides.* It is also anticipated that other environment-related technical courses will be available to the students as electives.

Detailed course guides are *not* included for the required support courses in the curriculum. The following pages list general recommendations for these support courses. The following is a list of the support courses described in this volume:

Math I	College Algebra & Trigonometry*
Math II	Technical Math with Calculus
Math III	Applied Calculus
Math IV	Applied Calculus with Differential Equations
Math V	Computer Programming
Math VI	Statistics**
Physics I	Fundamental Physics*
Physics II	Technical Physics*
English I	Fundamental Composition and Rhetoric*
English II	Technical Writing*
English III	Informative Speaking
Drafting I	Fundamental Drafting*
Mechanics I	Statics*
Mechanics II	Applied Strength of Materials*
Mechanics III	Dynamics
Surveys I	Plane Surveying*
Civil Engineering I	Engineering Construction Materials
Civil Engineering II	Elementary Structural Design
Economics	Engineering Economy

*Taken from *Wastewater Engineering Technology Programs.* Implemented by E. R. Baker, Clemson University, and W. A. Wockenfuss, University of Maryland. March 1978.

**Adapted from *A Two-Year Water Quality Monitoring Curriculum.* R. B. Glazer. Ulster County Community College, Stone Ridge, NY, 1975.

Mathematics I

College Algebra & Trigonometry

This course should enable the student to learn the fundamentals of algebra and trigonometry. After completing the course, the student should be able to solve interest problems and algebraic expressions involving polynomials and to use logarithms, as well as be familiar with most trigonometric functions and equations. The material covered in the course should include the following:

- Meaning of algebraic symbols
- Solution of linear equations
- Graphing of linear equations
- First-degree inequalities
- Absolute values of algebraic expressions
- Rational and radical expressions
- Binomials and polynomials
- Factoring
- Solution of quadratic equations
- Scientific notation and decimal notation
- Use of logarithm tables
- Graphing on semi-log and log-log graph paper
- Solution of interest problems
- Definition of basic trigonometric terms
- Measurement of sides of right, equilateral, isosceles, and oblique triangles
- Addition and subtraction of angles
- Construction of angles from function values
- Scalers and vectors
- Determination of sin, cosin, tangent, sec, csc and ctn of an angle
- Use of trigonometric function tables
- Graphing of trigonometric functions
- Use of the three Pythagorean relations in simplifying expressions
- Solution of trigonometric equations

PREREQUISITES FOR THIS COURSE

- High school algebra

RECOMMENDED INSTRUCTIONAL RESOURCES

Ambrose, William G. *College Algebra.* New York: MacMillan, 1976.
Eraut. *Fundamentals of Elementary Algebra: A Program for Self-Instruction.* New York: McGraw-Hill, 1970.
Heimer, R. T. et al. *Program in Contemporary Algebra,* rev. ed. New York: Holt, Rinehart and Winston.
Robinson, Thomas J. *Analytical Trigonometry,* 2nd ed. New York: Harper and Row, 1972.
Sagan. *A Programmed Approach to Trigonometry.* Encino, CA: Dickenson Publishing Co., 1973.

Mathematics II

Technical Math with Calculus

This course should enable the student to learn the fundamental concepts of calculus and analytical geometry. The material covered in the course should include the following:

Analytical geometry
Limits
Differentiation of rational functions
Differentiation of trigonometry functions
Integration of rational functions
Integration of trigonometric functions

PREREQUISITES FOR THIS COURSE

Math I

RECOMMENDED INSTRUCTIONAL RESOURCES

Goodman, A. W. *Analytical Geometry and the Calculus,* 3rd ed. New York: MacMillan, 1974.
Merriell, David M, *Calculus - A Programmed Text. Vol. I: Techniques and Applications, Vol. II: Theory.* Menlo Park, CA: W. A. Benjamin, 1973.

Mathematics III

Applied Calculus

The course should enable the student to learn basic applications of calculus in engineering technology. The material covered in the course should include the following:

- Coordinate planes and graphs of equations
- Functions and limits
- The derivative
- Applications of differentiation
- The integral
- Applications of integration
- Transcendental functions

PREREQUISITES FOR THIS COURSE

Math II

RECOMMENDED INSTRUCTIONAL RESOURCES

Shenk, Al. *Calculus and Analytic Geometry.* Santa Monica, CA: Goodyear Publishing Co., 1977.

Mathematics IV

Applied Calculus and Differential Equations

This course should allow the student to learn additional applications of calculus and ordinary differential equation uses for engineering technology. The material covered in the course should include the following:

- Techniques of integration
- Polar coordinates
- Taylors theorem and applications
- Infinite sequences and series
- Partial derivatives
- Maxima or minima with two or three variables
- Multiple integrals

PREREQUISITES FOR THIS COURSE

Math III

RECOMMENDED INSTRUCTIONAL RESOURCES

Shenk, Al. *Calculus and Analytic Geometry.* Santa Monica, CA: Goodyear Publishing Co., 1977.

Mathematics V

Computer Programming

This course should enable the student to learn to program a computer for engineering and scientific applications, using FORTRAN. The student should also become familiar with types of digital computers and their peripheral equipment. The material covered in the course should include the following:

Types of computers
Components of a digital computer system
Design and flowcharting of algorithms
Translation of flowcharts to machine code
Use of FORTRAN in running interpolations, solutions, searching, sorting, and data-handling
Use of subprograms and subroutines

PREREQUISITES FOR THIS COURSE

Math I

RECOMMENDED INSTRUCTIONAL RESOURCES

Crowley, Thomas H. *Understanding Computers.* New York: McGraw-Hill, 1967.
Friedman, J., et al. *Fortran IV* (Self-Teaching Guides Series). New York: John Wiley and Sons, 1975.

Mathematics VI

Statistics

This course should enable the student to determine the validity of data. The topics included in the course should include:

Organization and presentation of numerical data
Measures of central tendency and dispersion
Probability
Binominal and normal distributions
Random sampling
Hypotheses testing
Confidence limits
t-testing
Chi-square testing
Regression analysis
Correlation coefficients

PREREQUISITES FOR THIS COURSE

Math I

RECOMMENDED INSTRUCTIONAL RESOURCES

Brase, Charles. *Understanding Statistics-Concepts and Methods.* Indianapolis, IN: Heath, 1978.
Middlebrooks, E. Joe. *Statistical Calculations–Applications and Solutions.* Ann Arbor, MI: Ann Arbor Science Publishers Inc., 1977.

Physics I

Fundamental Physics

This course should enable the student to learn fundamental principles of mechanics and light. Emphasis should be placed on the laws of motion, conservation of energy, and the nature of light. The material covered in the course should include the following:

Newton's laws of motion
Acceleration, velocity, momentum, kinetic energy, potential energy
Relationship of work, force, and energy
Conversion of energy to work
Particle and wave theories of light
Reflection, refraction, frequency, wavelength, white light
Snell's law
Problems in the reflection and refraction of light
Superposition principle of waves

PREREQUISITES FOR THIS COURSE

Math I

RECOMMENDED INSTRUCTIONAL RESOURCES

Friedman, Charles P. and Strickland, James S. *Study Guides for PSSC Physics.* Washington, DC: Center for Personalized Instruction, Georgetown University, 1975.
Halliday, David and Resnick, Robert. *Fundamentals of Physics,* rev. ed. New York: John Wiley and Sons, 1974.

Physics II

Technical Physics

This course should enable the student to learn fundamentals of electricity, magnetism, thermal phenomena, and modern physics. Emphasis should be placed on electrostatic and magnetic forces, the laws of thermodynamics, quantum theory, and relativity. The material covered in the course should include the following:

- Coulomb's law
- Character of electrostatic forces
- Electric potential energy
- Current in a conductor and in a magnetic field
- Lorentz force
- Faraday's law
- Linz's rule
- First law of thermodynamics
- Carnot's theorem
- Ideal gas law
- Principle of relativity
- Lorentz-Fitzgerald transformation
- Alpha and beta particles and gamma rays
- $E = mc^2$

PREREQUISITES FOR THIS COURSE

Physics I

RECOMMENDED INSTRUCTIONAL RESOURCES

Friedman, Charles P. and Strickland, James S. *Study Guides for PSSC Physics.* Washington, DC: Center for Personalized Instruction, Georgetown University, 1975.

Halliday, David and Resnick, Robert. *Fundamentals of Physics,* rev. ed. New York: John Wiley and Sons, 1974.

English I

Fundamental Composition and Rhetoric

The student who completes this course should be able to write effectively and correctly. The material covered in this course should include the following:

Review of parts of speech
Review of sentence structure
Correction of grammatical and spelling errors in sentences
Review of punctuation and capitalization
Use of the dictionary to check spelling and definitions of words
Writing of themes or essays (with topic sentences of paragraphs clearly identified)

PREREQUISITES FOR THIS COURSE

High school English

RECOMMENDED INSTRUCTIONAL RESOURCES

Butler, Eugenia, et al. *An Auto-Instructional Text in Correct Writing,* 2nd ed. Lexington, MA: D. C. Heath and Co., 1975.
Feinstein, George W. *Programmed Spelling Demons.* Englewood Cliffs, NJ: Prentice-Hall, 1973.
Flesch, Rudolf and Lass, A. H. *A Guide to Better Writing.* New York: Popular Library, 1977.
Gowen, James A. *English Review Manual,* 2nd ed. New York: McGraw-Hill, 1970.
McCrimmon, James M. *Writing with a Purpose,* 6th ed. Boston: Houghton Mifflin, 1975.

English II

Technical Writing

This course should prepare the student to read and write technical reports and other typical business communications. Upon completion of this course, the student should be able to perform the following:

Write business communications such as order, inquiry and reply letters, and inter- and intra-office memorandums.
Correctly interpret data from long and short technical reports, case histories, project proposals, and research papers.
Write in clear and objective form a short technical report, a project proposal, and a case history.

PREREQUISITES FOR THIS COURSE

English I

RECOMMENDED INSTRUCTIONAL RESOURCES

Damerst, William A. *Clear Technical Reports.* New York: Harcourt Brace Jovanovich, 1972.
Ehrlich, Eugene A. and Murphy, Daniel. *Art of Technical Writing: A Manual for Scientists, Engineers, and Students.* New York: Apollo Editions, 1969.
Ulman, Joseph N. and Gould, Jay R. *Technical Reporting,* 3rd ed. New York: Holt Rinehart and Winston, 1972.

English III

Informative Speaking

The student should gain from this course knowledge for organizing, adapting and presenting speeches and oral reports on technical projects by manuscript, notes, and extemporaneously. The course will include the following subjects:

Distinctive nature and requirements of informative speaking
Appropriate situations for informative speaking
Investigation, selection, and arrangement of material
Clarity, accuracy, and style
Delivery

PREREQUISITES FOR THIS COURSE

English I
English II

RECOMMENDED INSTRUCTIONAL RESOURCES

Phillips, G. M. *Communications in Small Groups.* Indianapolis, IN: Bobbs Merrill, 1973.
Phillips, G. M., and Zolten, J. J. *Structuring Speech.* Indianapolis, IN; Bobbs Merrill, 1976.
Bryant, D. C., and Wallace, K. *Fundamentals of Public Speaking.* Englewood Cliffs, NJ: Prentice-Hall, 1976.
McBurney, J. H., and Wrage, E. J. *Guide to Good Speech.* Englewood Cliffs, NJ: Prentice-Hall, 1975.

Drafting I

Fundamental Drafting

This course should teach the student the basic methods of drawing plans of structures. The student should produce simple pencil and paper drawings; the drawings should be neatly lettered and drawn to scale. The material covered in the course should include the following:

Use of drafting tools
Lettering of drawings
Geomety of drawings - lines, arcs, etc.
Systems of projection - perspective, parallel, oblique, orthographic, isometric, angular
Multiview and auxiliary view drawings
Sectioning
Dimensioning
Tracing

PREREQUISITES FOR THIS COURSE

Math I

RECOMMENDED INSTRUCTIONAL RESOURCES

French, Thomas E. and Vierck, Charles J. *Engineering Drawing and Graphic Technology*, 11th ed. New York: McGraw-Hill, 1972.
Gieseche, F. E., et al. *Technical Drawing*, 6th ed. New York: MacMillan, 1974.
Hill, R. and Jensen, C. *Modern Engineering Tolerancing*. New York: McGraw-Hill, 1976.
Hoelscher, R. P., et al. *Graphics for Engineers: Visualizations, Communications and Design*. New York: John Wiley and Sons, 1968.
Jensen, C. H. *Engineering Drawing and Design*. New York: McGraw-Hill, 1968.
Knowlton, K., et al. *Technical Freehand Drawing and Sketching*. New York: McGraw-Hill, 1977.
Luzadder, Warren J. *Fundamentals of Engineering Drawing*, 7th ed. Englewood Cliffs, NJ: Prentice-Hall, 1977.

Mechanics I

Technical Statics

This course should teach the student the basic principles and applications of mechanics. The material covered should include the following:

Basic concepts of statics: forces, couples, and moments of couples and of forces
Resultants of force systems
Equilibrium of coplanar force systems
Centroids
Frictional forces
Fluid statics forces
Moments of intertia

PREREQUISITES FOR THIS COURSE

Math II

RECOMMENDED INSTRUCTIONAL RESOURCES

Beer, Ferdinand P. and Johnston, E. R. *Mechanics for Engineers: Pt. 1-Statics,* 3rd ed. New York: McGraw-Hill, 1977.
Ginsberg, Jerry and Genin, Joseph. *Statics.* New York: John Wiley and Sons, 1977.
Hibbeler, Russell C. *Engineering Mechanics: Statics and Dynamics.* New York: MacMillan, 1974.
Smith, Charles E. *Applied Mechanics: Statics.* New York: John Wiley and Sons, 1976.
Malvern, Lawrence E. *Engineering Mechanics: Vol I, Statics.* Englewood Cliffs, NJ: Prentice-Hall, 1976.

Mechanics II

Applied Strength of Materials

This course should enable the student to develop a clear understanding of the simplified expressions for the physical behavior of stressed bodies on which most engineering design rests, as well as the limitations of such expressions. The material covered should include the following:

Stresses and deformations due to centric loading
Shearing stresses and displacements due to torsional loading
Stresses and deflections in beams due to flectural loading
Combined loadings
Statically indeterminate beams
Columns analysis

PREREQUISITES FOR THIS COURSE

Mechanics I
Math II

RECOMMENDED INSTRUCTIONAL RESOURCES

Higdon, A. et al. *Mechanics of Materials.* New York: John Wiley and Son, 1976.
Jensen, Alfred and Chenoweth, Harry. *Applied Strength of Materials,* 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, 1974.
Olson, Gerner A. *Elements of Mechanics of Materials,* 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, 1974.
Popv, Howard P. *Mechanics of Materials,* 2nd ed. Englewood Cliffs, NJ: Prentice-Hall, 1976.

Mechanics III

Dynamics

This course should enable the student to apply calculus to the description of moving bodies and fluids. The material covered in the course should include the following:

Motion of a particle
Relative motion
Moments of inertia
Kinetics of translation rotation and plane motion
Work - energy relationships
Impulse - momentum

PREREQUISITES FOR THIS COURSE

Mechanics I
Math III

RECOMMENDED INSTRUCTIONAL RESOURCES

Beer, F. P. and Johnston, E. R. *Mechanics for Engineers.* New York: McGraw-Hill, 1976.

Surveys I

Plane Surveying

This course should enable the student to learn the basic techniques of surveying and their application to field work. The importance of accurate note-taking and of taking proper care of surveying instruments should be stressed throughout. The material covered should include the following:

Basic surveying terminology
Types of surveys
Methods of measurement
Identification and correction of errors in measurement
Taping and chaining
Use of the transit in measuring angles and running traverses
Reading and making maps

PREREQUISITES FOR THIS COURSE

Math I
Drafting I

RECOMMENDED INSTRUCTIONAL RESOURCES

Herubin, Charles A. *Principles of Surveying.* Englewood Cliffs, NJ: Reston (distributed by Prentice-Hall), 1974.
McCormack, Jack S. *Surveying.* Englewood Cliffs, NJ: Prentice-Hall, 1976.
Royer, King. *Applied Field Surveying.* New York: John Wiley and Sons, 1970.

Civil Engineering I

Engineering Construction Materials

This course should enable the student to learn the origin and use of construction materials, characteristics and use of soils, aggregates, portland cement, bituminous plastics, and metals as construction materials. The material covered should include:

Aggregates - types, sources, properties, and uses
Construction cements
Bituminous materials-types and uses
Soils - classifications, properties, and compaction
Plastics and fiber glass - types, properties, and uses
Metals - types, properties, and uses

PREREQUISITES FOR THIS COURSE

Mechanics II

RECOMMENDED INSTRUCTIONAL RESOURCES

Portland Cement Association. *Design and Control of Concrete Mixtures.* Skokie, IL: Portland Cement Association, latest edition.
Asphalt Institute. *Mix Design Methods for Asphalt Concrete.* College Park, MD: The Asphalt Institute, latest edition.
American Society for Testing and Materials. *Annual Book of ASTM Standards.* Philadelphia, PA: ASTM, latest edition.
Herubin, C. A. and Marotta, T. W., *Basic Construction Materials.* Reston, VA: Reston, 1977.

Civil Engineering II

Elementary Structural Design

In this course the student should learn the elements of structural design and detailing in timber, steel, and reinforced concrete; design specifications; use of handbooks; and structural drafting practice.

Forces and stresses
Moments and reactions
Shear and bending moment
Deflection in beams
Moment distribution - beams
Theory of bending
Steel beams, columns
Steel connections - bolted, riveted, and welded
Wood beams, columns
Wood trusses, connections, analysis
Trusses design
Reinforced concrete stresses
Reinforced concrete, beams, floor systems, columns
Footings
Ultimate strength design
Cantilever retaining wall

PREREQUISITES FOR THIS COURSE

Mechanics II

RECOMMENDED INSTRUCTIONAL RESOURCES

Parker, H. and Hauf, H. D. *Simplified Engineering for Architects and Builders,* 5th ed., New York: John Wiley and Sons, 1975.

Economics

Engineering Economy

In this course the student should learn the basic fundamentals of engineering economics; cost calculations for engineering projects and business operations; and time value of money. The following subjects will be covered:

Basic concepts and equivalence
Interest formulas and interest problems
Annual cost
Present worth
Rate of return
Benefit-cost analysis
Depreciation methods and effects on taxes
Multiple alternatives
Break even and sensitivity analysis
Increment costs and utility rates

PREREQUISITES FOR THIS COURSE

Math I

RECOMMENDED INSTRUCTIONAL RESOURCES

Grant, E. L. et al. *Principles of Engineering Economy.* New York: Ronald, 1976.
Dorfman, Robert and Dorfman, Nancy S. (ed.) *Economics of the Environment - Selected Readings.* New York: W. W. Norton and Co. Inc., 1972.

APPENDIX I
WATER QUALITY MANAGEMENT FUNCTIONS IN PENNSYLVANIA*

A. **Program Areas**

1. **Water Pollution Control**

   Sewage Collection/Treatment
   Industrial Waste Treatment
   Mine Drainage
   Erosion and Sediment Control
   Storm Water Management
   Non-point Source Control

2. **Water Supply**

   Surface and Ground Water
   Source/Treatment/Distribution

3. **Water Resources**

   Protection/Conservation/Allocation

4. **Water Quality**

   Standards and Criteria

5. **Beaches and Pools**

6. **Water Obstructions**

   Dams and Encroachments

B. **Job Titles within Bureau of Water Quality Management**

Sanitary Engineer
Environmental Protection Specialist
Environmental Protection Technician
Planning Analyst
Hydraulic Engineer
Chemist
Biologist
Geologist
Administration/Clerical/Secretarial

C. **Sanitary Engineers Currently Perform the Following Related Tasks**

201 and 208 Planning**
Facility Design Review***
Enforcement: Laws, Regulations, Policies**
Public Participation**
Negotiation**
Emergency Preparations**

*From Pete Slack, Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management

**It is anticipated that a BET in WQM would fill similar positions planning, enforcement, public participation, negotiation, and emergency preparations.

***It is anticipated that a BET in Operation and Design would fill these positions.

APPENDIX II
LICENSING

The engineering technology graduate plays an important role in solving the water quality problems of the United States. A large portion of the work needed to be done in the water pollution area can be performed by engineering technologists. Open to the graduate of the four year Bachelor of Engineering Technology (BET) program are several routes for professional registration. One is certification by the Institute for Certification of Engineering Technicians (ICET) as a *Certified Engineering Technician.* The study by the National Society of Professional Engineers (NSPE) of graduates of accredited four year programs in engineering technology revealed that 43% of BET graduates were titled *engineers* at the entry level and an impressive 57% were titled *engineers* after a period of experience and maturity.* Only 33% were hired as *technician* and only 28% retained the technician title. Certification as an *Engineering Technician*, therefore, appears to be of very little professional benefit to the vast majority of graduates of Bachelor of Engineering Technology programs.

Registration as a planner is also a potential route of acknowledging professional expertise and character for those involved in the water quality management area. A few states have a Registration Board for Planners but it is not part of a national affiliation. Future professional proficiency in planning will be indicated by one's membership in the American Institute of Planners.** Membership requires education, experience and examination in the planning field.

There is currently no registration of engineering technologists by ICET and NSPE and, in fact, recommendations were made not to initiate such a program.

Registration as an *Engineer-in-Training* (E.I.T.) and ultimately registration as a Professional Engineer (P.E.) is therefore the preferable method of professional growth for the BET graduates. The Task Force Report concluded that:*

> In the judgment of the Task Force, a bachelor's degree in engineering technology is comparable in educational value to a bachelor's degree in any other discipline related to engineering, albeit the emphasis on curricular subject matter produces graduates with asymmetrical talents. The baccalaureate degree in engineering technology or science is not intended to prepare for a career as a "Professional Engineer." Thus, the B.E.T. should be considered a technician upon graduation. If a physical science major chooses to embark on an engineering career, he must reinforce his undergraduate work with additional study and/or experience in engineering principles and practical skills, while if an engineering technology graduate elects to pursue professional engineering, he must augment his educational background with a deeper and broader understanding of basic engineering principles, higher mathematics, additional physical science, and a richer exposure in the humanities.
>
> The Task Force recommends that bachelor degrees in related science and engineering technology be considered parallel starting gates into professional registration, and that a mandatory experience and study period of at least two years be required to supplement the non-engineering degree. At the end of this period, the state registration board will exercise its authority

*National Society of Professional Engineers. *Report of Task Force on Four Year Technology.* Washington, DC: NSPE Pub. No. 2009 M & N 3-73. Revised 2-75.

**American Society of Planning Officials "Memorandum" Chicago, IL: September 1978.

*National Society of Professional Engineers. *Report of Task Force on Four Year Technology.* Washington, DC: NSPE Pub. No. 2009 M & N 3-73. Revised 2-75.

to allow or forbid the applicant to sit for the Engineering Qualifying Examination, as outlined in Figure 1. Upon passing the examination, the applicant will acquire a status comparable to that afforded all others undergoing the process of professional registration, as prescribed by the various state laws.

An ECPD accredited bachelor's degree in engineering should remain the only direct route acceptable to professional registration as indicated in Figure 1. Any other combination of accredited education, advanced study and appropriate experience must be acceptable to the state registration board within the limits established by state law.

Most state Professional Engineers Boards offer the engineering fundamentals (E.I.T. exam) and technical specialty (P.E. exam) exams as separate tests of proficiency that can be taken at different times, the engineering fundamentals always first. Most states also permit the senior engineering students to take the E.I.T. exam. It is recommended that B.E.T. students be permitted to take the E.I.T. exam during the last semester of their senior year as is currently done in several states. It is also recommended that the graduates continue to be called engineering technologists and not technicians. Graduates of other science-related disciplines are not arbitrarily called technician nor should engineering technologists be called technicians except when they perform the traditional technician tasks. The National Council of Engineering Examiners (NCEE) has taken the position that:*

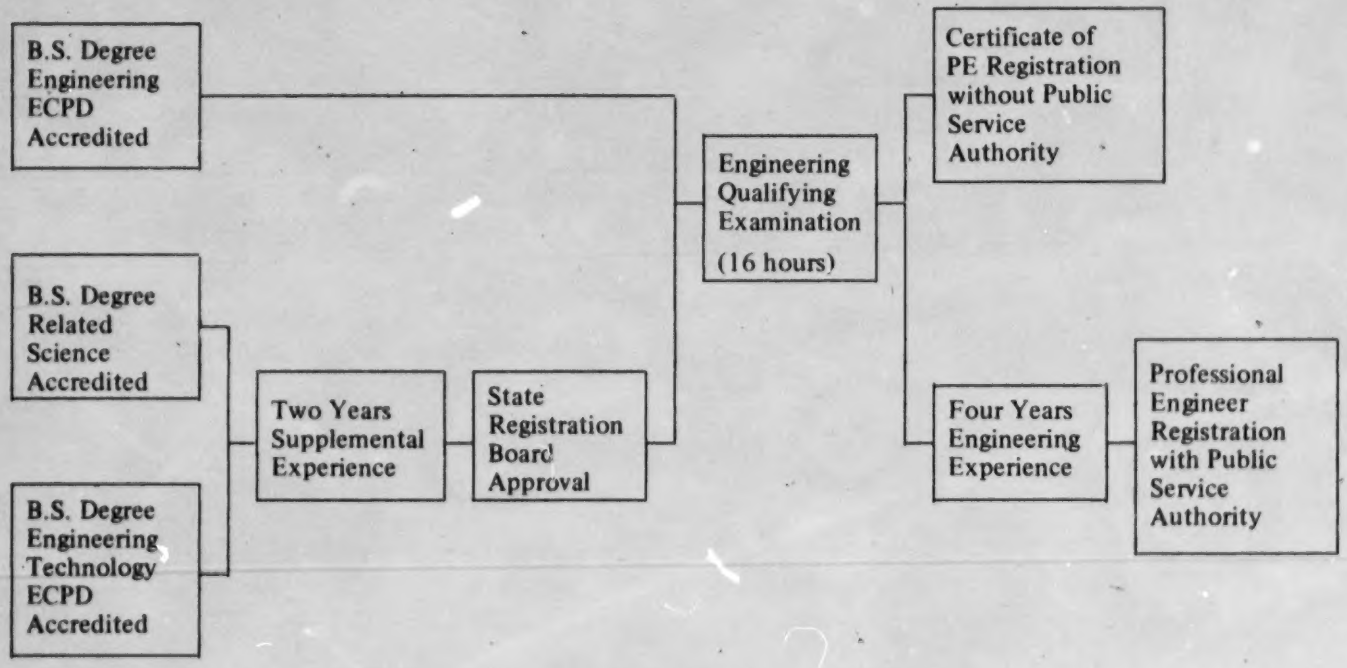
After January 1, 1979 any applicant for certification as E.I.T. and after January 1, 1983 any applicant for licensing to practice engineering; Must have Bachelor of Science in Engineering from ECPD accredited school, 4 year program, or: Equivalent education in a university or other institution determined by the State Board of Registration to be acceptable to the Board.

CONCLUSIONS AND RECOMMENDATIONS

The graduates of a B.E.T. program in water quality management need some professional measure, guarantee, and recognition of their expertise. At present, registration as an engineering technologist does not exist, nor is it anticipated, and registration as an engineering technician does not appear suitable since most tasks performed by the B.E.T. graduate require greater skills and fundamental knowledge. Therefore, it is recommended that the curriculum for training persons in Water Quality Management follow the guidelines set up by ECPD for bachelor of engineering technology graduates. It is also recommended that the students take the E.I.T. exam during the last semester of their bachelor of engineering technology education and upon meeting the experience requirements be permitted to take the P.E. exam.

*National Council of Engineering Examiners. *Synopsis: State Engineering Registration Laws and Policies and Procedures of State Boards.* Seneca, SC: NCEE, 1977.

Figure 1 – Modified 1969 NSPE Recommendations for Minimum Qualifications


B.S. Degree Engineering ECPD Accredited
B.S. Degree Related Science Accredited
B.S. Degree Engineering Technology ECPD Accredited
Two Years Supplemental Experience
State Registration Board Approval
Engineering Qualifying Examination (16 hours)
Certificate of PE Registration without Public Service Authority
Four Years Engineering Experience
Professional Engineer Registration with Public Service Authority

APPENDIX III
PROFESSIONAL ACCREDITATION

Solution to environmental pollution in the U.S. over the past decade (and it will probably be the same in the next) has been a plan, design, implementation, and operation sequence. Many of the human functions in this sequence can be defined in terms of engineering technology.

The Engineers Council for Professional Development (ECPD) appointed a subcommittee as early as 1944 to investigate standards for technical education.* By 1964 this subcommittee became a standing committee and established a basis for accrediting technical programs now designated as programs in engineering technology. The programs considered are technological in nature and in the field of higher education. They defined Engineering Technology as the set of skills closest to the engineer requiring application of scientific and engineering principles in support of engineering activities. The term *engineering technologist* is reserved for graduates of baccalaureate programs.

The American Society of Civil Engineers has prepared guidelines to assist ECPD accreditation teams. Environmental engineering technology often falls within the general area of civil engineering technology and they make note of such coverage within their guidelines. They offer the following definitions for guidance of ECPD visitors in correlating academic programs with the needs of the profession:**

Civil Engineering

The civil engineer, working in his full professional capacity, is a conceptualizer, planner and designer of new and innovative engineering works and systems and/or the operating manager of complex technical systems or business enterprises. In this role he must utilize technical knowledge of great sophistication and he also must employ his understanding of the interrelationships of the economic, social, political and environmental issues that are frequently the key matters in decision-making today. The civil engineer is expected to make judgments that extend well beyond the technical domain. To prepare a civil engineer for his role requires an educational program of technical depth and finesse and also of breadth.

Basic programs in civil engineering begin the education of an individual for the role of the professional civil engineer. However, work experience in engineering practice during an engineer-in-training period, and advanced study in engineering and/or management are usually strong contributing factors in an individual's achievement of his professional capacity as a civil engineer.

Civil Engineering Technologist

The civil engineering technologist works in close support of engineers and architects translating conceptual ideas into functioning systems and providing supervisory direction for the implementation of these ideas by technicians and craftsmen. The technologist is principally an implementer of the technical aspects of large projects or systems. This implementation may be manifested in his role in the written and graphical aspects of project documentation, in the design of standardized subsystems, or in the overseeing of manufacturing or construction activities.

The term *civil engineering technologist* is applied to the graduate of four-year

*Engineers Council for Professional Development, *Engineering Technology Accreditation Report, 1977.* 45th Annual Report, Vol. 3. New York: EPCD, 1977.

**American Society of Civil Engineers. *Guide for Civil Engineering Technology Visitors on ECPD Accreditation Teams.* New York: ASCE, 1976.

bachelor's degree curricula in civil engineering technology, or related curricula such as construction and environmental technology.

Because of his key role as an implementer, the technologist's education must provide him with sufficient technical knowledge and skills to permit him to make independent judgments that will expedite the work without jeopardizing its effectiveness, its safety, or its cost.

Civil Engineering Technician

In the practice of civil engineering, the technician will usually work under the immediate supervision of a civil engineer or a civil engineer technologist. He performs operational tasks of a technical nature following well defined methods and procedures set down by his supervisors or by engineering standards, and he is not expected to make judgments requiring marked deviations from these procedures without consultation. The technician's tasks often include sampling and collection of data, testing, computation, written and graphical presentation of results, field layout of work according to plans, and field inspection.

The term *civil engineering technician* is applied to the graduates of college level associate degree curricula or to persons who have received comparable training through on-the-job experience and/or training programs.

The tasks of the civil engineering technicians require understanding and skills in engineering principles, manual techniques, and communication modes in order for him to communicate with his supervisors and to execute his task effectively.

The second and third paragraphs of the description of a civil engineering technologist are the keys to the application of the Bachelor of Engineering Technology graduate to water quality management. It is readily apparent that the BET is trained to be an implementor.

The ECPD has set up procedures for accrediting associate and baccalaureate degree programs. The following excerpts highlight the important procedures and criteria for the evaluation:*

METHOD OF EVALUATION

An institution's engineering technology educational programs will be evaluated on the basis of data submitted by the institution to ECPD in the form of a questionnaire, reactions by employers to the performance of graduates, together with reports of an on-site visit by a carefully selected team drawn from the official engineering technology and ad hoc visitors' list . . . . . .

Following these activities, the reports of the on-site visitation committee are reviewed by the Engineering Technology Committee and the latter's evaluations and recommendations are submitted to the ECPD Board of Directors.

CRITERIA

Engineering technology programs may be accredited at the associate degree level or at the baccalaureate level. Differential criteria are specified as the minimum course requirements for each level. The criteria relate to the following:

1. The program performance in producing associate degree graduates from programs meeting minimum course criteria and displayed employer satisfaction with these engineering technicians . . . . . .

*American Society of Civil Engineers. *Guide for Civil Engineering Technology Visitors on ECPD Accreditation Teams.* New York: ASCE, 1976.

2. The program performance in producing baccalaureate graduates from programs meeting minimum course criteria and displayed employer satisfaction with these engineering technologists.

A survey of graduates' employers will be made to determine if evidence of the rating of satisfactory performance as engineer technologist exists.

The curricular content of accreditable baccalaureate programs in engineering technology will normally be expected to include:

A. The equivalent of three-fourths academic year of basic sciences and mathematics with the proportion of mathematics dependent upon the needs of the particular technological area.

B. At least the equivalent of one and one-half academic years of technological courses, including technical science, technical specialty, and technical electives.

C. At least the equivalent of three-fourths academic year in communications, humanities, and social science courses (not to include physical education or ROTC).

D. The specifications listed above total three years of the four years required for a baccalaureate in a well-rounded engineering technology program. The additional time is available for the implementation of the educational objectives of the individual and the institution.

E. A minimum of 120 semester hour credits for a baccalaureate.

F. The total program should reflect adequate work and student progress throughout the four years to warrant the conferring of a baccalaureate.

Criteria listed in 1 and 2 are now discussed as providing a minimum foundation of an engineering technician or engineering technologist. The program content should provide an integrated educational experience directed toward development of the ability to apply pertinent knowledge to the solution of practical problems in the graduate's engineering technology specialty. The remainder of the program may be applied to meeting the overall aims of the institution and the objectives of the individual student.

ECPD requires a high degree of specialization for engineering technology programs, but with field orientation rather than task orientation. The engineering orientation of the technical specialization should be manifest by faculty qualifications and course content.

Communications, Humanities, and Social Sciences – There will be variation among institutions on the specific courses offered in this general area. Perhaps the only courses that might be expected to be common would be English courses. Sufficient depth and scope should be present to provide exposure to engineering technology's role as it affects other sciences and impacts on societal factors.

Basic Sciences and Mathematics – Allocations within this group between basic sciences and mathematics will depend partly upon the specific program needs. For example, electronics might require a higher fraction of the total in mathematics than environmental engineering technology, which may have a greater basic sciences requirement. The study of computer programming and/or statistics, although often not meeting the restric-

tive definitions of basic science and mathematics, may be included in this category in satisfying the quantitative requirement.

A. Basic Sciences – In a study of science, the objective is to acquire fundamental knowledge about nature and its phenomena. Toward this end, the courses should emphasize the understanding, measurement, and quantitative expression of the phenomena of nature. Laboratory work, including experimentation, observation, and accurate measurement, is an important part of the study of physical science. The basic sciences components of an engineering technology program may include physics, chemistry, and the life and earth sciences in accordance with specific program needs. Subjects selected for study should provide foundation knowledge for work in technological courses.

B. Mathematics – College algebra is the normal beginning point for the study of mathematics in engineering technology programs. Program requirements should include carefully selected topics, suited to the individual program, from algebra and trigonometry and going beyond to higher levels of mathematics in baccalaureate programs, particularly, the study of the concepts and applications of calculus should be included in the program to ensure that students are professionally literate and to permit use of this mathematical tool in technological courses.

Study of the concepts of calculus shall also be included in associate degree programs unless alternate subjects in mathematics beyond algebra and trigonometry are specified in the applicable specific program guidelines as developed by the professional societies and approved by ECPD.

Technical Sciences – Subject matter in an engineering technology program has its roots in mathematics and basic science and carries knowledge further toward application. Courses are designated to supply the core of technological knowledge the student needs in his chosen profession. With more emphasis on application than the "engineering science" of an engineering program, the same subject areas are included.

Technical Specialty – Three subdivisions are identified:

A. Technical Skills and Techniques – These are courses in which the student would acquire the necessary skills and knowledge of appropriate methods, procedures, and techniques – such as graphics, problem solving, processes, surveying, construction techniques, instrumentation techniques, production methods, field operation, and maintenance.

Technology laboratory manuals, experiments, projects, and activities should clearly reflect the orientation of the program towards the education of the student in the modern techniques of applied design, construction, operation, maintenance, testing and some production processes.

B. Technical Design Courses – These would be courses in practice-oriented standard design applied to work in the field – such as construction – in which the student acquires experience in carrying out established design procedures in his own area of specialization. The key to this type of technical design lies in the fact that the courses would follow established design concepts developed by engineering and that there would be prime emphasis on standard design procedures and practices. Many of these design methods have already been included in handbooks or standard computer methods for various branches of engineering. These courses would require an understanding of the application of mathematics and science to such activities as air conditioning systems design, duct design, piping design, amplifier design, computer component and circuit, and/or civil engineering technology applications such as surveying or road design.

C. Technical Electives – Technical electives would include any courses which support the student's career interests, not only additional mathematics, basic science, technical science, and supportive courses from other disciplines (i.e., electronic circuits for a student in mechanical engineering technology) but also labor relations, cost accounting, contracts and specifications, etc.

Free Electives – The student should be allowed a stipulated minimum number of free electives credits.

Remedial Work – Remedial courses, designed to remove deficiencies in the background of entering students, are inherently at a level lower than expected in college credit work. Such courses, particularly in the areas of mathematics and communications, are not to be used to meet the minimums in curricular content requirements.

Program Arrangement – Some baccalaureate engineering technology programs have been developed using a single continuous four-year curriculum structure; others are organized on a "two-plus-two" or a "three-plus-one" plan wherein upper level studies area added to associate degree level work to form a baccalaureate degree program . . . . . .

Upper division programs generally accept students from accredited associate degree programs. Students from non-accredited associate degree programs should have appropriate validation of their work. It is expected that those students with deficiencies in their background preparation for the upper division programs will be required to remove those deficiencies. In all cases, the accreditation process is intended to insure that the graduate has achieved a level of competency expected in a baccalaureate program.

For those upper division programs that continue the technical speciality, their courses should be structured on a "building block" basis: i.e., the advanced courses in the technical speciality should have as prerequisites the technical courses including mathematics from the associate degree. These courses should obviously demonstrate a greater degree of sophistication and theory than those in the associate degree program . . . . . .

Under no circumstances should an upper division program that is predominately management-oriented be considered an engineering technology program, nor

should two associate degree programs back-to-back be considered for baccalaureate accreditation.

Flexibility in the development of appropriate work experiences, such as a formal cooperative program, as part of an engineering technology program is encouraged. Work experience components will be evaluated as part of the evaluation of an entire engineering technology program. The Engineering Technology Committee will not separately identify cooperative programs.

3. The faculty adequacy in numbers, competence, and the standards of instruction that it maintains in all subject areas that supply instruction to engineering technology students.

   The faculty determines the adequacy of an engineering technology program. It is axiomatic that instructional goals will be achieved only to the level of faculty competence and vision.

4. The admission of students, school policy on scholastic work, and the adequacy of operations for student advising, selective retention, and application of graduation requirements.

   Entrance requirements should be high school graduation or the equivalent .....

5. Administrative policy and effectiveness of leadership and the effects on teaching.

   A capable faculty can perform its function best in an atmosphere of good relations with the administration. This requires good communication between faculty members and administrators, and a mutual concern with policies that affect the faculty.

   The college administration should have four basic roles: selection, supervision, and support of the faculty; selection and supervision of the students; operation of the facilities for the benefit of the faculty and students; and interpretation of the college to members of the profession and to the public.

   In performing many of these functions, the administrators should not operate alone, but should seek advice from individual faculty members, faculty committees, and special consultants.

6. Financial and facility support and availability as a measure of institutional dedication to the educational goals of engineering technology education.

   ECPD is concerned that financial and facility provision are adequate as predictors of continuing quality in education and evidence of program stability. Faculty salaries sufficient to attract desirable candidates for open positions and to provide a reasonably stable staff at the institution and within technology departments are a major factor.

   Adequate facilities in classrooms and laboratories are central to effective achievement of educational goals. Provisions for updating equipment in response to changing practices in technology is important. The availability of sufficient expendable materials to give students proper learning experiences is another essential to achieving goals. Laboratory manuals, experiments, and projects should clearly indicate that the facilities are being used to educate the student in modern techniques of applied design, construction, operation, maintenance, testing, production processes, etc.

It is particularly important that instruction in engineering technology be conducted in an atmosphere of realism. Theory courses should stress problem identification and solution, with emphasis on the quantitative, analytical approach including the making of "order of magnitude" estimates quickly. They should be accompanied by coordinated laboratory experiences, including measurement, collection, analysis, interpretation, and presentation of data.

Laboratory equipment should be of the type that would be encountered in industry and practice. Since one of the objectives of engineering technology programs is the development of technical skills, each student should be thoroughly familiar with the use and operation of analytical or measurement equipment common to his major field of study. Experience in the operation of standard of basic shop equipment such as lathes, welders, and engines does not, in itself, meet this requirement.

Equipment catalogs, professional magazines, journals and manuals of industrial processes and practices should be readily accessible and used by the technology student in addition to the usual library resources. The student should be familiar with the literature of his technology and encouraged to use it as a principal means of staying abreast of the state of the art in his technological field. Library usage is one indication of faculty interest in developing student skills in locating and utilizing information.

The computer has become one of the important and versatile tools in engineering practice. The technologist, as a part of the engineering team, must acquire an understanding of its capacities and limitations in his field of technology, and should develop some facility in its use for solving problems. Technology students should have access to digital computer equipment, and should use computers to acquire the knowledge and skills described.